Web-based prediction of extubation outcome in premature infants on mechanical ventilation using an artificial neural network

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Abstract: The web-based implementation of a decision-support tool for the prediction of extubation outcome in mechanically ventilated premature infants enables the integration of advanced and computationally intensive modeling approaches with easy-usage, no maintenance requirements and wide availability. Accordingly, the artificial neural network predictive tool developed provides decision-support in determining whether to extubate a premature infant to clinicians in NICUs anywhere with access to the Internet.

Description of problem and specific purpose of the system: Approximately 470,000 babies (~12%) are born prematurely in the US each year. Virtually all infants born at ≤ 27 weeks gestation, ~80% of those delivered between 27 and 30 weeks gestation, and approximately 30% of the infants born between 30 and 32 weeks of gestation (FPoP 1997) (~2% of total) require endotracheal intubation and intermittent positive pressure ventilation starting soon after birth. Even though ventilator technology and monitoring of premature infants has improved immensely over the past decades, there are still no standards for weaning and determining optimal extubation time for those infants. Approximately, 30% of intubated preterm infants will fail attempted extubation, requiring reintubation and resuming of mechanical ventilation (Kavvadhia et al. 2000). Other infants actually ready for extubation are overlooked in the busy NICU and subjected to unnecessary risks of developing volutrauma, barotrauma, retinopathy (ROP), bronchopulmonary dysplasia (BPD), and chronic lung disease (CLD).

Decision-making whether or not to extubate a premature infant is extremely complex, involving a large amount of information that is in part processed subconsciously and based largely on clinical experience. A decision-support tool can be used to aid inexperienced clinicians in their decision-making. The tool can alert clinicians in situations where the NICU is overcrowded and extremely busy and infants potentially ready for extubation can be overlooked. Such a decision-support tool can assist in decreasing the number of false-positive (i.e. infants that were extubated too early) and false-negative (infants that could have been extubated earlier) cases. Less infants extubated too early or not early enough would lower the risk for re-intubation, prolonged ventilation and their associated risks, such as volutrauma, barotrauma, ROP, BPD, and CLD. Clinicians using a decision-support tool need to rely on the accuracy of the prediction. This goal can be accomplished by providing measures of reliability such as a novelty index along with the prediction.

A web-based decision-support tool was developed consisting of two components, the user interface implemented in Hypertext Markup Language (HTML) and the mathematical model employing an artificial neural network (ANN), a state of the art artificial intelligence machine learning technique. A series of ANN was developed using a data with 51 variables collected on 183 infants. Using the sensitivities returned by the median performing ANN, a forward variable addition procedure was implemented. The best performing ANN with the median absolute difference between the areas under the ROC curves for training and independent validation set was determined. The final ANN used 13 input variables, had one hidden layer containing 7 hidden nodes and an area under the ROC curve of 0.87. The ANN implemented in the decision-support tool returns the prediction score along with a novelty index to user. This information enables the user to apply the most appropriate threshold in the determination whether to categorize the prediction into success or failure. Code implementation is entirely on the server side, under UNIX operating system, Apache web-server and MATLAB scientific computing programming environment.